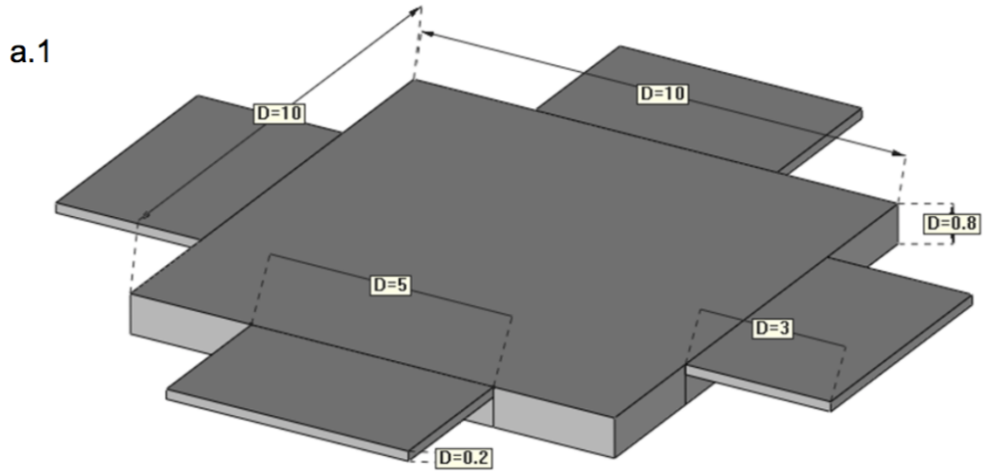
COMPUTATIONAL STRUCTURAL MECHANICS AND DYNAMICS

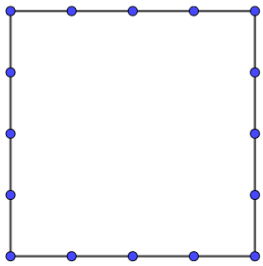
Assignment 2: PLATES

Assignment 2.1

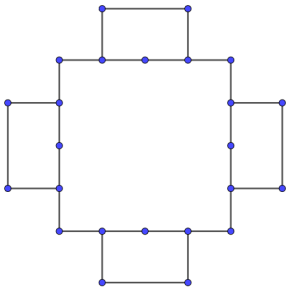
In this assignment, we were asked to determine the different characteristics to pursue with a FEM study on the following structure:



To begin with, we determine that this structure will be considered as a 5 different elements. To do this, it will be necessary to divide every side of the main square in 4, so we can make coincide the rectangular elements to it.

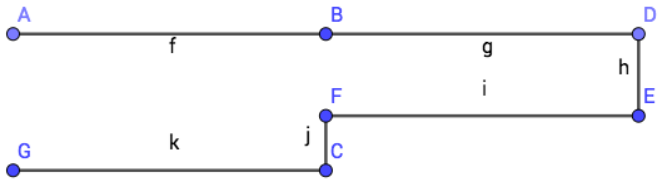


As we can see, the square sides are divided in 4 segments, this will provide enough nodes for the lateral parts. Which at the end will look something like this:



For the edges of this system we will have to take into consideration that the sides of the small rectangles have not the same width as the main square base. For this, we are going to set two different base of coordinates.

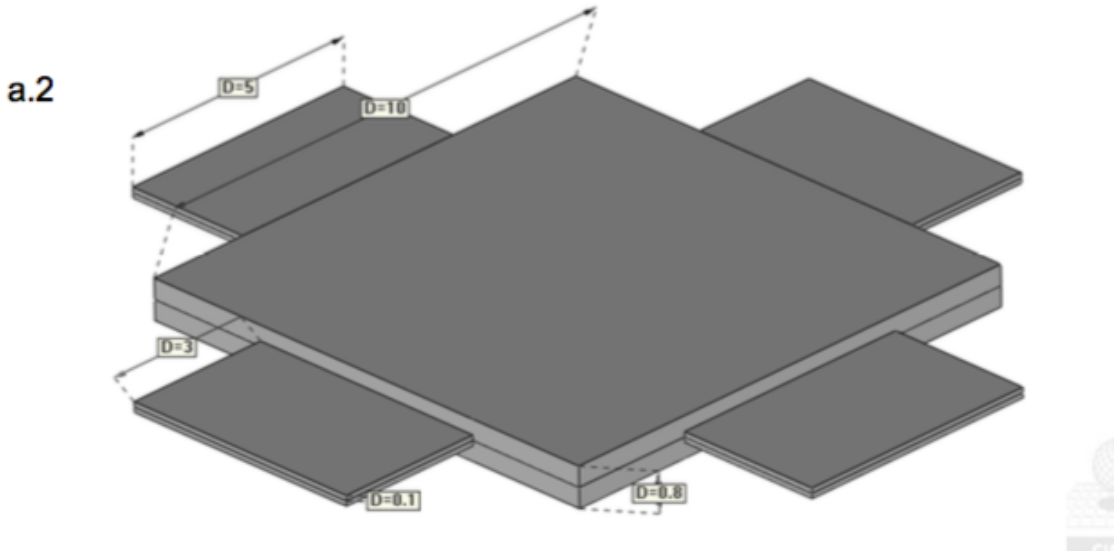
To deal with the problem of offset from the smaller plates to the square one we will have to change the system of references to the top plane, so every time we build and extrude, it will be done from the top surface, where the two structures coincide, such as:



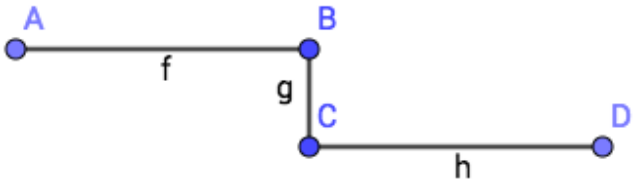
Where this is the profile of our structure, and “f” “k” represent the square and “g” and “i” the small rectangle next to it.
We will use rectangular elements (as it’s the more logical choice because of this geometry) and Kirchhoff elements based theory will work fine in this case.

Assignment 2.2

For problem number 2 we won’t have to think about this kind of complications because the axis of both plates are the same for both systems.



With this kind of profile, it will be much easier to model the structure using 5 different elements and giving each of them its width. The half profile would be in this case something like:

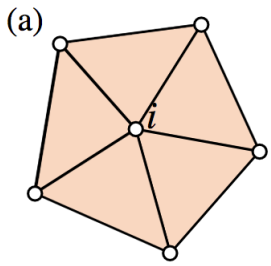


As we can see, there is no need to do anything like the previous case, but, as before, if the rectangle's thickness/width is equal or lower to 0.1 it means that the Kirchhoff's discrete thin plates can be used in the case we consider all plates as thin plates.

Assignment 2.3

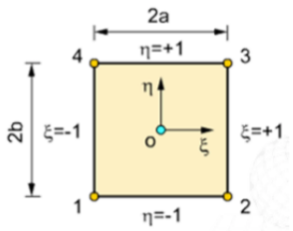
The patch test consists in 2 different tests with similar objectives (displacements/forces).

The first one consists in taking a bunch of nodes surrounding another node and apply to them a displacement, for example, in the Y direction and see that the node in the middle (in which there's no displacement applied to) will move in the same direction and the same length as the other nodes. This test can be equally done by forces.



In this case we are asked to do so with the MCZ plate element, which takes this form:

MZC plate element



$$w = \sum_{i=1}^{4} \left[N_i w_i + \bar{N}_i \left(\frac{\partial w}{\partial x}\right)_i + \bar{\bar{N}}_i \left(\frac{\partial w}{\partial y}\right)_i \right]$$

$$\begin{cases} N_i = (1+\xi_i\xi)(1+\eta_i\eta)(2+\xi_i\xi+\eta_i\eta-\xi^2-\eta^2)/8 \\ \bar{N}_i = a(\xi^2-1)(\xi+\xi_i)(1+\eta_i\eta)/8 \\ \bar{\bar{N}}_i = b(\eta^2-1)(\eta+\eta_i)(1+\xi_i\xi)/8 \end{cases}$$

In the case we add a lateral displacement in X direction to the nodes 1-2-3-4 and taking into account 0 strain forces, the displacements in 0 will be exactly as the ones from 1-4 nodes.